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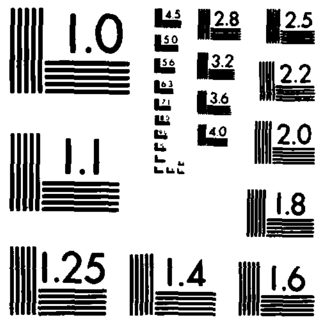

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US Army Corps of Engineers

AD-A155 555

COMPUTER-AIDED STRUCTURAL ENGINEERING (CASE) PROJECT

INSTRUCTION REPORT K-84-11

USER'S GUIDE FOR COMPUTER PROGRAM CGFAG, CONCRETE GENERAL FLEXURE ANALYSIS WITH GRAPHICS

by

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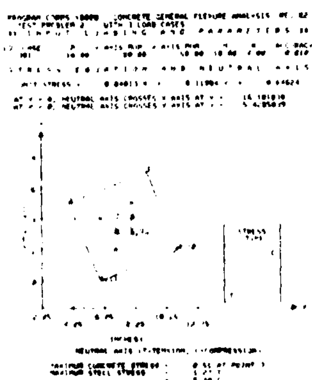

US ARMY ENGINEER WATERWAYS EXPERIMENT STATION

September 1984

Final Report

Approved For Public Release. Distribution Unlimited

AUTOMATION TECHNOLOGY CENTER

Prepared for

DEPARTMENT OF THE ARMY
US Army Corps of Engineers
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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Instruction Report K-84-11	2. GOVT ACCESSION NO. AD-A155 555	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) USER'S GUIDE FOR COMPUTER PROGRAM CGFAG, CONCRETE GENERAL FLEXURE ANALYSIS WITH GRAPHICS		5. TYPE OF REPORT & PERIOD COVERED Final report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) William A. Price III Harvey Miller Marjorie L. Waites E. T. Gates		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Engineer Waterways Experiment Station Automation Technology Center PO Box 631, Vicksburg, Mississippi 39180-0631		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Computer-Aided Structural Engineering (CASE) Project
11. CONTROLLING OFFICE NAME AND ADDRESS DEPARTMENT OF THE ARMY US Army Corps of Engineers Washington, DC 20314-1000		12. REPORT DATE September 1984 13. NUMBER OF PAGES 39
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Available from National Technical Information Service, Springfield, Virginia. 22151. This report was prepared under the Computer-Aided Structural Engineering (CASE) Project. A list of published CASE reports is printed on the inside of the back cover.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

CGFAG (Concrete General Flexure Analysis with Graphics), (Computer Program)
Concrete products--testing--computer programs (LC)
Structural dynamics--computer programs (LC)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This user's guide is designed to analyze cross sections of reinforced and nonreinforced concrete as they are subjected to any combination of axial loads and bending. This program is one of the oldest examples of computerized structural analysis. Its versatility in classifying irregular cross sections, bolted baseplates, and unreinforced sections has sustained a demand for it from its origin to the present.

(Continued)

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20. ABSTRACT (Continued).

The program has been used for numerous applications through manipulation of the ratio r . The phase for differentiation of nonreinforced sections has been implemented to theorize footing pressure and to make stability analyses.

The recent revisions can be credited with making output easier to interpret and providing the new capability, graphics output of the geometry and stress equation calculation. The format allows for the output to be separated into a summary page and a page of detailed stress tables.

This ratio governs development of the transformed area of reinforcement in compression. It is actually the ratio of the effective modulus of the reinforcement in compression to that of the reinforcement in tension.

ELECTRONIC COMPUTER PROGRAM ABSTRACT

TITLE OF PROGRAM			PROGRAM NO.	
Concrete General Flexure Analysis - CGFAG (X8008)			713-F3-R0010	
PREPARING AGENCY U. S. Army Engineer Waterways Experiment Station, Automatic Data Processing Center, P. O. Box 631, Vicksburg, MS 39180-0631				
AUTHOR(S)	DATE PROGRAM COMPLETED	STATUS OF PROGRAM		
		PHASE	STAGE	
E. T. Gates, SWGAD H. L. Miller, NPS	December 1974	MOD	OP	

A. PURPOSE OF PROGRAM

Elastic analysis of combined axial load plus biaxial bending on a cracked section, with stress always proportional to strain. Reinforcing steel is optional; bars in compression may be evaluated separately from bars in tension, enabling analysis of general surfaces-in-contact problems as well as reinforced concrete.

B. PROGRAM SPECIFICATIONS

The program is written in FORTRAN 66 with the Graphics Compatibility System. The CORPS system library time-sharing file name is X8008. Output includes optional graphics display.

C. METHODS

Working from an initial assumption that the neutral axis is on the coordinate X-axis, the program adds the correction terms to the stress equation until the neutral axis is located precisely enough to compute stresses within the specified precision (default precision is 0.1 percent).

D. EQUIPMENT DETAILS

Time-sharing computer (Honeywell level 66, CDC Cyber, or Harris 500) Remote terminal:

Tektronix 4014, if graphics display is desired;

any printing terminal if graphics display is not desired.

E. INPUT-OUTPUT

Input (from saved file or interactive) consists of problem name, concrete outline and steel pattern I.D. Nos., x and y coordinates of corners of concrete outline and of single bars or end bars of rows, bar areas, loading values of P, Mx, and My, n = Es/Ec, r = fs/nfc, precision. Output (at terminal or into file) includes data echo, stress equation and neutral axis location, optional tables of stress at each coordinate point and bar row end, and optional graphics picture of section with neutral axis location.

F. ADDITIONAL REMARKS

1. Program origin - Seattle District, 1967.
2. Manipulation of input data values of n and r will permit analysis of base plates, contact bearing, and homogeneous materials.
3. Documentation can be obtained from Engineering Computer Programs Library, WES, P. O. Box 631, Vicksburg, MS 39180-0631.
4. Program is part of the CORPS and is available on several computer systems.

PREFACE

This user's guide documents a computer program that performs a service-load working-stress analysis of an irregular cross section of concrete, reinforced or not. This is an enhanced version, with graphics, of a program originated in 1967 in the US Army Engineer District, Seattle. The work on the enhanced version was accomplished using funds provided to WES by the Directorate of Engineering and Construction, Office, Chief of Engineers, US Army (OCE), under the Computer-Aided Structural Engineering (CASE) Project.

This program was first written in the North Pacific Division by H. L. Miller, E. T. Gates, et al. The work in modifying the original program was then done by Mr. William A. Price III, Chief, Engineering Applications Group (EAG), Scientific and Engineering Applications Division (SEAD), Automation Technology Center (ATC), US Army Engineer Waterways Experiment Station (WES), and Mrs. Marjorie L. Waites, Computer Assistant, EAG.

Dr. N. Radhakrishnan, Chief, ATC, and Mr. Paul K. Senter, Research Group, SEAD, coordinated work on the program.

Commander and Director of WES during the publication of this report was COL Robert C. Lee, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
inches	0.0254	metres
square inches	0.00064516	square metres
kip/square inches	6.894757	pascals

USER'S GUIDE FOR COMPUTER PROGRAM CGFAG, CONCRETE GENERAL FLEXURE ANALYSIS WITH GRAPHICS

PART I: INTRODUCTION

Background

1. This program is a product of 17 years of evolution, which began in the US Army Engineer District, Seattle. The revisions incorporated in this latest version have brought the original Concrete General Flexural Analysis (CGFA) into the contemporary world of flexible time-sharing, equipped with optional graphics display and control of the amount of output detail. The updated version is named CGFAG, that is CGFA with graphics. The 1983 revisions separated the stress tables from the rest of the printout and made them an optional page 2. The graphics and a new, brief, stress summary were added to the problem data echo and called page 1. So that the program can be run from nongraphics terminals, the graphics output on page 1 is optional (paragraph 27).

Purpose and Capabilities

2. The program is designed to perform a cracked-section working stress analysis of a concrete cross section, reinforced or nonreinforced, of any shape. The cross section may contain a number of voids and/or composite external areas. The (optional) reinforcing steel may be arranged in any pattern and may act at a modular ratio of zero, n, or $2n$ when in simultaneous compression with a tensile modular ratio of n. Thus, it can analyze nonreinforced concrete, reinforced beams, reinforced columns, or bolted bearing plate pads. Applied service loads may include axial loads plus biaxial moments.

Limitations

3. The concrete cross section is described by a series of successive straight-line segments connecting the corners of the outline. Thus, a curve

is approximated by a series of short segments. The number of corners between segments is limited to not more than 99 (paragraphs 19 and 20).

4. Reinforced steel, if used, is described in rows where a row may contain any number of bars that are of the same size and equally spaced. A row may contain one or more bars and may have any orientation relative to the coordinate axes. The number of rows is limited to not more than 100 (paragraph 21).

5. Each loading contains one axial force, assumed to be applied at the coordinate axes' origin, plus superimposed moments about the two coordinate axes. The superimposed moments must include the moments caused by translating the axial force from its actual location. There is no limit on the number of loadings that may be applied. There is no provision for combination loads; each force and moment set is analyzed separately. (Paragraphs 22 through 24 present more information on loading data lines.)

PART II: COMPUTER PROGRAM

6. This program was designed to determine the location of the neutral axis and the stresses in a given section of concrete or reinforced concrete subjected to certain conditions. These conditions could be any combination of axial load, P, applied at the intersection of the x-y axes in a direction perpendicular to them, and the moments M_x and M_y about the x-y axes. The concrete section is defined by coordinates; the reinforcement by center bar coordinates; rows of uniform sized bars by end bar coordinates, the number of bars, and their size. The program gives the equation of the neutral axis, the stress at each point on the concrete section defined by a set of coordinates and the stress in each single bar or for the end bars in rows. This program is written in ANSI FORTRAN with the Graphics Compatibility System.

Analysis and Method of Solution

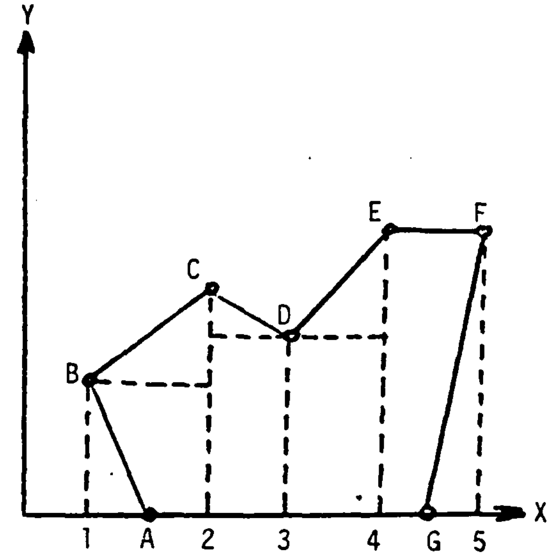
7. The program computes the stresses in cross sections of concrete subjected to any combination of axial loads and bending in accordance with the general flexure formula:

$$f = \frac{P}{A} + \left[\frac{M_{x_o} - M_{y_o}\dfrac{I_{x_o y_o}}{I_{y_o}}}{I_{x_o} - \dfrac{(I_{x_o y_o})^2}{I_{y_o}}}\right] X_o + \left[\frac{M_{y_o} - M_{x_o}\dfrac{I_{x_o y_o}}{I_{x_o}}}{I_{y_o} - \dfrac{(I_{x_o y_o})^2}{I_{x_o}}}\right] Y_o$$

which can be written $f = a + bx + cy$, the equation of the neutral axis when $f = o$. This simplified equation is written in the program output. The method followed in the computation is one of successive iterations to find the neutral axis that satisfies the above equation. Nomenclature in the above equation and the computation are described in a publication by the California

State Highway Department.* The computation is in accordance with AASHO** and Saville.†

8. The values necessary for this general flexure formula are obtained by summing the properties of the section's subdivisions. The section is subdivided by dropping perpendiculars from each end of a bounding line segment to the X-axis, Section ABCDEFGA. Points must be listed clockwise around the section and each subdivision is assumed to consist of a rectangle and a triangle. The area of the triangle may be zero, 4EF5; the area of the rectangle may be zero, AB1, or both may be zero, GA. For each triangle and rectangle, the area, the coordinates of the centroid, x and y, and the moments of inertia of the area about the X, Y, and XY-axes are computed. The areas and moments of inertia are accumulated to obtain totals for the section, the values of Ax and Ay are also accumulated to determine the centroid of the total section. A similar computation is carried out for the reinforcement to obtain the properties of the transformed section. The principal difference is that the general term is evaluated for a row of bars, instead of the series that would be generated by taking them one at a time.



9. Normally, the first iteration is computed on the assumption that the entire section is in compression. This assumption will give a first location of the neutral axis. With the location of the neutral axis, only the subdivisions which have concrete in compressive stress will be computed. The

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* California State Highway Department. "Reinforced Concrete Columns Subject to Unsymmetrical Bending and Direct Stress," Bridge Design Practice, Section 5, Appendix A.

** American Association of State Highway Officials. 1949. "Concrete Design Columns Flexure and Direct Stress," Standard Specifications for Highway Bridges, Article 3.7.10(d).

† Saville, William G. S. 1940. "Analyzing Non-Homogeneous Sections Subjected to Bending and Direct Stress," Civil Engineering, Vol 10, No. 3, pp 170-172, New York, N. Y.

intersections of the section with the neutral axis are computed each time there is a reversal of the sign of stress between points of the section. The tensile area is then subtracted, leaving the concrete area in compression only as part of the transformed section. The sign of the stress in each bar of steel is checked and a value for use in computing the transformed section is assigned to it as previously determined by the designer who developed the data.

10. After the first iteration, a table of the concrete stresses is developed. As the stress at each point is computed, it is compared with the value of the difference of the stresses and compared with the desired accuracy read into the computer. When the change in successively computed stresses for all points on the concrete section is less than the desired accuracy, iteration will cease and the results of the last iteration will be printed. When the number of iterations exceeds 200, the computer will type out each iteration number, and continue computing.

11. Three items are placed with the loadings on the load case line which provide great flexibility and control over the program. Supplied for each case is n, the ratio of the modulus of elasticity of the steel in tension to that of the concrete in compression. This ratio governs the development of the transformed area of the reinforcement in tension. The ratio "r" which governs development of the transformed area of reinforcement in compression is also given. This value is actually the ratio of the effective modulus of the reinforcement in compression to that of the reinforcement in tension. The values of n and r may be shown by the expressions

$$r = \frac{E_s \text{ (compression)}}{E_s \text{ (tension)}}$$

and

$$n = \frac{E_s \text{ (tension)}}{E_c \text{ (compression)}}$$

The ACI 318* code allows a value of 2 to be used. For further discussion of the use of variable r, see paragraph 13. The third item is listed as limit

* American Concrete Institute. 1977. Commentary on Building Code Requirements for Reinforced Concrete," ACI 318-77, Detroit.

of accuracy desired. This is the maximum allowable value of the change of stress in the concrete between successive iterations and, as such, sets the accuracy of the computation.

12. The computed values are printed in fixed decimal format, except for the neutral axis intercepts on the coordinate axes, which are in a format similar to that of a scientific pocket calculator. The accuracy of the input and its value (0.001 is recommended) will determine the accuracy of the printout.

13. The program has been used for many applications through the manipulation of the ratio r. A bolted bearing plate was analyzed by using $r = 0$. This removed the bolts from the compression area while those in the tension area remained fully active. With $r = 1/n$, walls containing untied steel have been analyzed. With these values of r and n the compression area appeared to be solid concrete.

14. The program, as written, will analyze nonreinforced sections. This phase of the program has been used to analyze the pressure on footings and make stability analyses. If the loading places the entire section in tension, a solution will not be obtained and excessive iterations will result. The solution does not allow tension in the concrete, and if the material being analyzed can sustain tension, it will be necessary to code a hypothetical network of bars. This network must cover the possible tensile zone and use an n value of 1 and an r value of zero so that these hypothetical bars will act like concrete. Such a network could be rows of bars on 1-in.* centers and a bar area of 1 in.^{2}

15. Hollow sections can be analyzed without program modification. The hollow shape is regarded as an enlarged cut into the outline, leaving a saw cut (of finite, small width) into the void and an enlarged cavity forming the void. Points are clockwise around the outside outline and counterclockwise around the void space(s). Thus, the outline area is added in summation, while the void(s) are subtracted. The two sides of the "saw cut" must not touch, but may be very close (approximately ±0.01 in.). The coordinates must be arranged along one continuous line, closing on the starting point. The starting coordinates must also be the last set.

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* A table of factors for converting non-SI units of measure to SI (metric) units is presented on page 3.

Data Preparation

16. Input data are in standard FORTRAN free-field format, with a comma or at least one blank space between values. Integer values must not show a decimal point; real numbers with whole values may be entered without the decimal point. Every line must start with a line number of less than 999,999. The program will read, but ignore, the line numbers. Several data sets may be placed in sequence in the data file, and will be described later. One set is described below. A complete input guide, in outline form, is shown in paragraph 26.

Label line

17. Up to 66 columns of alphanumeric problem identification begin after the first blank character (space) following the line number. Characters beyond column number 66 will be ignored.

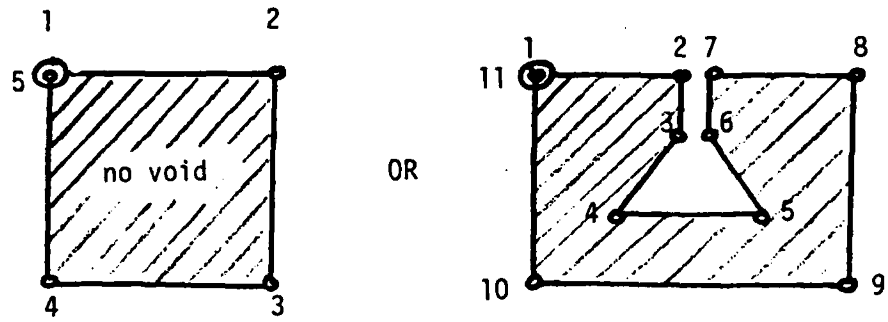
Header line

18. There are four integer numbers in this sequence: line number, at least one blank space; the number of concrete data points (including the required repeat of the first set); the number of steel data lines; and the number of load data lines. If the concrete outline is to be repeated from the previous problem, there should be no concrete data given for the repeat.

Concrete data lines

19. Use as many lines as are needed (up to 100), but each line must have the following arrangement: line number (integer), at least one blank space; concrete outline identification number (integer, 6 digits maximum, the value from the last concrete data line will be used in the printout); three sets of coordinates: X-coordinate (decimal), Y-coordinate (decimal). Coordinates must be less than 100,000 in. If the previous problem had the same concrete outline, the concrete data lines may be omitted if shown as such on the header line.

20. The concrete coordinate point sets are placed in ascending sequence around the concrete outline, three sets per data line, proceeding clockwise around the outside and counterclockwise around any void(s) inside. No more than 100 points may be coded. A square includes five sets of coordinates according to the need to repeat the first set at the end:



Steel data lines

21. One line of steel data may define one bar or one straight line of equally spaced bars. All of the bars on one data line must have the same cross-sectional area. No more than 100 lines of steel data may be used. Each line is coded thus:

- a. One bar on the line: the line number; at least one blank space; a steel pattern identification number (integer, eight digits maximum, the value from the last steel data line will be used in the printout); the cross-sectional area of the bar (decimal); the X-coordinate of the bar location (decimal, must be less than 100,000.0); the Y-coordinate of the bar (decimal, must be less than 100,000.0); and a numeral "1" (for one bar).
- b. A row of bars on the line: the line number; at least one blank space; a steel pattern identification number (integer, six digits maximum, the value from the last steel line will be used in the printout); the cross-sectional area of one bar in the row (decimal); the X-coordinate of end number 1 of the row (decimal, must be less than 100,000.0); the Y-coordinate of the row (decimal); the number of bars in the row (integer); the X-coordinate of end number 2 of the row (decimal); and the Y-coordinate of end number 2 of the row (decimal).

Loading data lines

22. The loading data are described by an axial force (concentrated), the moment about the Y-axis (the sum of both the effect of the concentrated force and of any other applied moments), called Mx , and the moment about the X-axis (the sum of both the effect of the concentrated force and of any other applied moments), called My . The sign convention is that positive indicates compression by the axial force and compression in the first quadrant (X and Y both positive) by the moments. Lengths and distances are in inches. Force may be in kips or pounds, as long as consistent units are maintained throughout the problem. Each loading condition is listed on a separate line and the number of loading cards must be as shown on the header line.

23. Action of the program in assigning stress ratios to the steel is ontrolled by two variables on the loading data line. The ratio Ex/Ec , "n," is as defined in ACI 318. The ratio "r" is as defined and discussed in paragraph 11. Typical values of these two items are illustrated:

USE	n	r
Normal reinforced concrete beam	Es/Ec	1.0
Column with increased modular ratio for compressive steel	Es/Ec	2.0
Bolted bearing plate, bolts take tension only	E_{bolts}/Ec	0
Concrete section with bars in compression at concrete stress (no ties) (Para 13)	Es/Ec	1.0/n
No reinforcing (Para 14)	1.0	1.0

24. Each load data line is made up as follows: the line number, at least one blank space, a load case identification number (integer, six digits maximum) that will be printed in the load description table, the axial load (decimal), the moment Mx about the Y-axis (decimal), the moment My about the X-axis (decimal), the modular ratio "n" (decimal), the ratio "r" (decimal), and the desired accuracy of the final concrete stresses (decimal, same units as the output stresses). There is no limit to the number of loading data lines.

Special lines

25. Following the last problem, there should be a special pair of lines in the data file, so that the program will end without error messages. The first line of the pair should have a line number with at least one blank. The second line of the pair should have a line number, no less than one blank, and three zeroes separated by a comma or at least one blank space. Failure to do this will cause an error message "OUT OF DATA IN SREAD," but causes no actual errors.

Input Guide

26. Paragraph references cite the narrative descriptions within this report. A thorough study of paragraph 16 is important before beginning preparation of a data file.

a. Label line--reference paragraph 17. As many as 66 characters of text will be printed at the beginning of each analysis. Subsequent problems must start with this line.

b. Header line--reference paragraph 18 for details.

LN NP NSL NLL

where

LN = Line number.

NP = Number of concrete data points; 100 max, including the required last point that is a repeat of the first point. Use a value of zero and omit the concrete data lines if the outline is to be repeated from the previous problem in the data file.

NSL = Number of steel data lines; 100 max. Use a value of zero and omit the steel data lines if the section is to be unreinforced.

NLL = Number of load case description lines, no limit.

c. Concrete data lines--reference paragraphs 19 and 20. Use number of lines needed to define NP points, three points per line.

LN IDC X_n Y_n X_{n+1} Y_{n+1} X_{n+2} Y_{n+2}

where

LN = Line number.

IDC = Concrete outline identification number, 6 digits maximum. This is shown in the printout.

X_n = X-coordinate of the first point described in this line of data. Maximum value = 100,000 inches, must be positive.

Y_n = Y-coordinate of the first point on the line.

The line should be stopped here, or the rest of the line should be all zeroes, if point n was the last point needed to complete the outline description (including the repeat of the first point).

X_{n+1} = X-coordinate of the second point on the line.

Y_{n+1} = Y-coordinate of the second point on the line.

The line should be stopped here, or the rest of the line should be all zeroes, if point n+1 was the last point needed to complete the outline description (including the repeat of the first point).

X_{n+2} = X-coordinate of the third point on the line.

Y_{n+2} = Y-coordinate of the third point on the line.

d. Reinforcement data lines--reference paragraph 21. Use one line per row of bars, one or more bars per row where all bars in one row are the same size and are equally spaced. If the section is unreinforced, use zero for NSL in the header line and omit the

reinforcement data lines. A row of bars may have any orientation and rows may cross each other.

LN IDS ABAR X_1 Y_1 NBAR X_2 Y_2

where

LN = Line number.

IDS = Steel pattern identification number, 6 digits maximum. This is shown in the printout.

ABAR = Area of one bar, square inches. If more than one bar in the row, all bars must have the same area and be equally spaced.

X_1 = X-coordinate of end number 1 of a row or, if only one bar, of this bar. 100,000.0 inches maximum.

Y_1 = Y-coordinate of end number 1, inches, 100,000.0 max.

NBAR = Number of bars in the row.

If NBAR is one, stop the data line here.

X_2 = X-coordinate of end number 2 of the row, if NBAR > 1. 100,000.0 inches maximum.

Y_2 = Y-coordinate of end number 2 of the row, if NBAR > 1. 100,000.0 inches maximum.

e. Load case data line--reference paragraphs 22 through 24. One such line per load case, no limit on number of lines, but number used must be the value of NLL on the header line.

LN IDL P M_x M_y n r ACC

where

LN = Line number.

IDL = Load case identification number, 6 digits maximum, will be printed in output.

P = Axial force, kips, compression positive.

M_x = Moment about the Y-axis, including that caused by P and its location relative to x=0. Inch-kips, positive to cause compression in the cross section.

M_y = Moment about the X-axis, including that caused by P and its location relative to y=0. Inch-kips, positive to cause compression in the cross section.

n = Ratio of modulus of elasticity of steel in tension to that of the concrete in compression, E_s/E_c. See paragraphs 11 and 23.

r = Ratio of modulus of elasticity of steel in compression to that of steel in tension. See paragraphs 11 and 23.

ACC = Desired minimum accuracy of stress computations. If zero, a value of 0.001 ksi will be used.

f. Another problem may be placed here, beginning with the label line.

g. Last line, after the last load case data line of the last problem--two lines:

LN 2B

LN 0 0 0

where

LN = Line numbers.

2B = At least two blanks.

0 = Three zeroes, separated by at least one blank, after the line number and its blank space.

Output

27. All output values and input data will be in the same units with the sample problems illustrating output. The tables of stresses in concrete and steel are optional; the maximum values of each are always shown. When running the problem from a Tektronix 4014 graphics terminal, the text output is controlled to avoid lost or overwritten printout, and a picture of the cross section is shown, indicating the neutral axis.

Error Messages

28. Several error messages are built into the program. These messages and the problems they refer to are listed below.

a. "FILE READ ERROR" -- self-explanatory.

b. Concrete Data:

"Y"(n) MISSING" -- an X-coordinate was found, but no Y-coordinate; n is the sequence number of the data point.

"ERROR IN DATA FOR CONCRETE LINE n" -- an empty data line (line number only) was encountered in the data file.

c. Steel Data:

"BARN(n) MUST READ ZERO OR 1" -- both X and Y coordinates for end Number 2 coordinates were missing but more than 1 bar was indicated in the bar quantity variable "BARN."

"X2(n) MUST BE ZERO FOR ONE BAR IN ROW" -- if there is only one bar in a row, there is no end Number 2 for coordinates to define.

"ERROR IN DATA FILE FOR STEEL LINE n" -- more than seven or fewer than four data items on the line, follow the line number. The value of "n" denotes the sequence number of the line in the steel data line group.

d. Loading Data:

"ERROR IN LOAD DATA LINE" -- the next data line following last line printed had line number with no data to follow.

Remarks

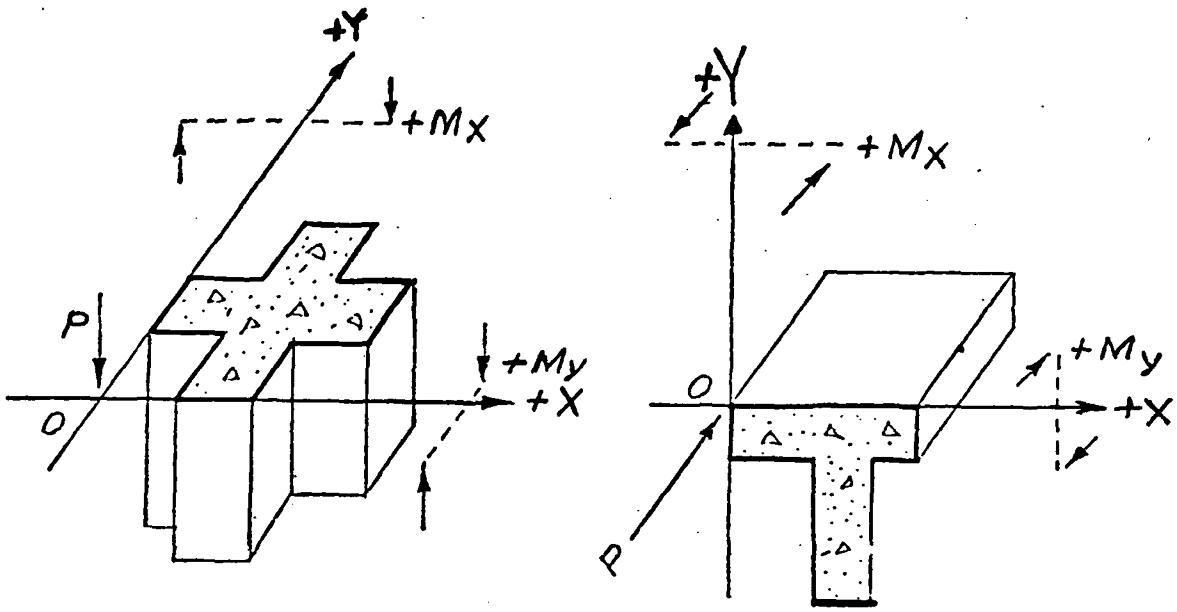
29. Program X0009 -- CGFARD, 713-F3-R0011, will generate part of the data file for one or more circular cross sections. An abstract of this program is included as Appendix A and its use is illustrated in sample problem 4.

Sign Convention

30. The sign convention for this program is presented in Figure 1. The symbols denoting variables are for clarity and do not represent actual variable names in the program.

Illustrations

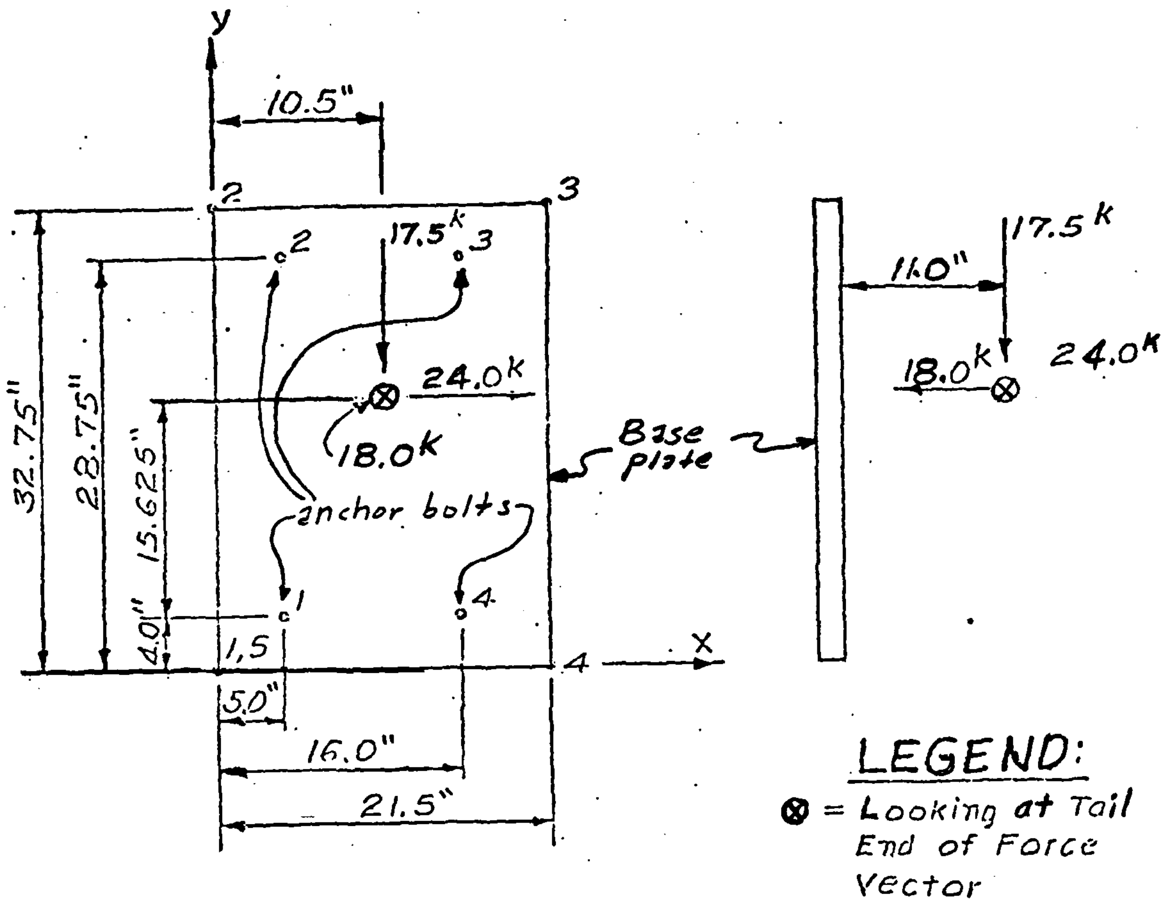
31. The following illustrations are shown to exemplify the program and they appear as sample problems 1 through 4.



The axes may be placed anywhere on or off the section. The axial load, P , must act at the origin, M_x and M_y must include the effect of moving P from its actual point of application. A positive moment will cause compression in the +X , +Y quadrant.

Figure 1. Sign convention

32. <u>Sample Problem 1.</u> Baseplate. Structures Port Arthur H-F Protection, closure structure at sta 1453+20.



<u>Bottom Hinge-Gate Open</u>

$$\text{(About y Axis)}\ M_x = 18.0(10.5) + 24.0(11.0)$$
$$= 189.0 + 264.0$$
$$= 453.0''^{k}$$

$$\text{(About x Axis)}\ M_y = 18.0(19.625) - 17.50(11.0)$$
$$= 353.5 - 192.75$$
$$= 160.75''^{k}$$

$$P = 18.0^{k}$$

```
*LIST CGFAD1

2000 CGFA TEST PROBLEM 1 -- TAKEN FROM HINGE BASE PLATE, PORT ARTHUR
2010  5  4  2
2020  1  0  0  0  32.75  21.5  32.75
2022  1  21.5  0  0  0
2030  2  1.41  5  4  1
2032  2  1.41  5  28.75  1
2034  2  1.41  16  28.75  1
2036  2  1.41  16  4  1
2040  3  18  453  160.75  9.2  0  0.01
2042  4  18  453  160.75  9.2  0  0.001

*FRN WESLIB/CORPS/X8008,R
```

```
ENTER 0 IF USING GRAPHICS TERMINAL.
   OR 1 IF NOT.
-0

COMPUTER WILL PAUSE TO ALLOW OUTPUT COPYING.
HIT CARRIAGE RETURN TO CONTINUE.

ENTER 1 TO GET DETAILED STRESS TABLES,
   OR 0 TO GET MAXIMUM VALUES ONLY.
*1

INPUT NAME OF DATA FILE.
INCLUDE 'CAT$PASS/FILENAME$PASS'  ONLY, NO USER ID
IF YOU WISH TO INPUT DATA FROM TERMINAL, ENTER A
CARRIAGE RETURN.
 ? CGFAD1
```

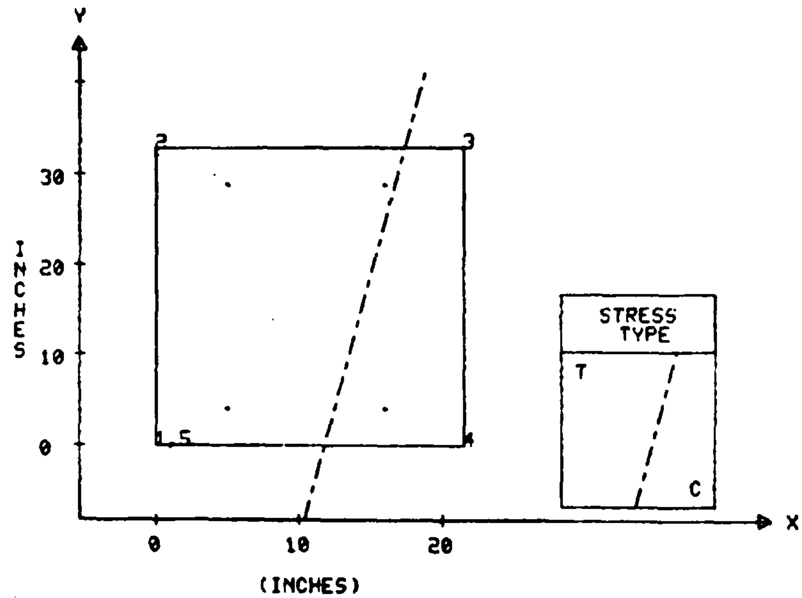
PROGRAM CORPS/X8008   CONCRETE GENERAL FLEXURE ANALYSIS   REV 82
CGFA TEST PROBLEM 1 -- TAKEN FROM HINGE BASE PLATE, PORT ARTHUR
** I N P U T   L O A D I N G   A N D   P A R A M E T E R S **

LD. CASE	P	Y-AXIS MOM.	X-AXIS MOM.	N	R	ACCURACY
3	18.00	453.00	160.75	9.20	0.	0.010

S T R E S S   E Q U A T I O N   A N D   N E U T R A L   A X I S:

UNIT STRESS =   0.03187 X   +   -0.00546 Y   +   -0.37519

AT Y = 0, NEUTRAL AXIS CROSSES X-AXIS AT X =   11.772075
AT X = 0, NEUTRAL AXIS CROSSES Y-AXIS AT Y =   -68.675287



----- NEUTRAL AXIS (T=TENSION, C=COMPRESSION)

MAXIMUM CONCRETE STRESS =   0.31 AT POINT 4
MAXIMUM STEEL STRESS   =   3.43 T

COMPRESSIVE STRESS IS SHOWN PLUS, TENSION MINUS (CONC. & STEEL)

C O N C R E T E   S T R E S S E S   F O R   O U T L I N E   1:

POINT	X-COORD	Y-COORD	COMPRESSIVE STRESS	POINT	X-COORD	Y-COORD	COMP. STRESS
1	0.	0.		2	0.	32.75	
3	21.50	32.75	0.131	4	21.50	0.	0.310
5	0.	0.					

S T E E L   S T R E S S E S   F O R   P A T T E R N   NO.   2:

AREA OF ONE BAR	QUAN. OF BARS/ROW	ROW END	X COORDINATE	Y COORDINATE	STRESS IN BAR
1.410	1		5.000	4.000	-2.187
1.410	1		5.000	28.750	-3.431
1.410	1		16.000	28.750	-0.205
1.410	1		16.000	4.000	0.

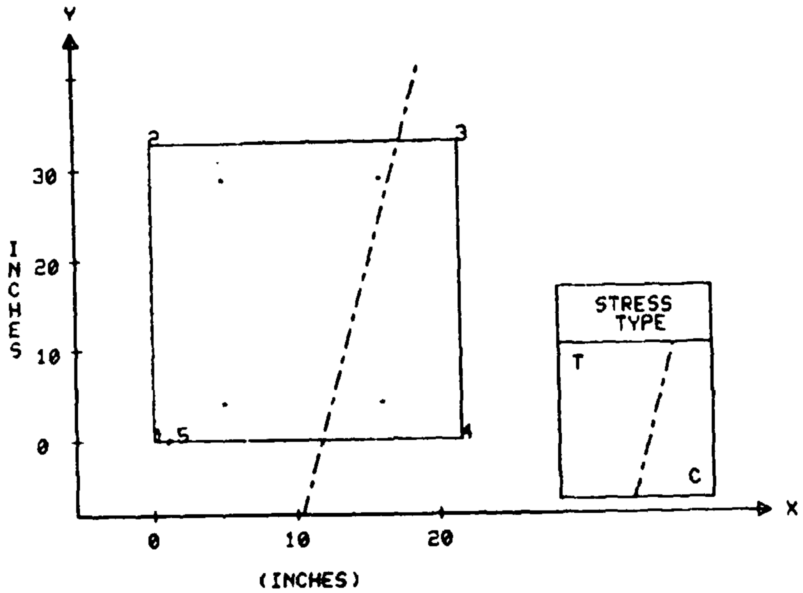
PROGRAM CORPS/X8008 CONCRETE GENERAL FLEXURE ANALYSIS REV 82
CGFA TEST PROBLEM 1 -- TAKEN FROM HINGE BASE PLATE, PORT ARTHUR
** INPUT LOADING AND PARAMETERS **

LD. CASE	P	Y-AXIS MOM.	X-AXIS MOM.	N	R	ACCURACY
4	18.00	453.00	160.75	9.20	0.	0.001

STRESS EQUATION AND NEUTRAL AXIS:

UNIT STRESS = 0.03187 X + -0.00546 Y + -0.37519

AT Y = 0, NEUTRAL AXIS CROSSES X-AXIS AT X = 11.772075
AT X = 0, NEUTRAL AXIS CROSSES Y-AXIS AT Y = -68.675287



----- NEUTRAL AXIS (T=TENSION, C=COMPRESSION)

MAXIMUM CONCRETE STRESS = 0.31 AT POINT 4
MAXIMUM STEEL STRESS = 3.43 T

COMPRESSIVE STRESS IS SHOWN PLUS, TENSION MINUS (CONC. & STEEL)

CONCRETE STRESSES FOR OUTLINE 1:

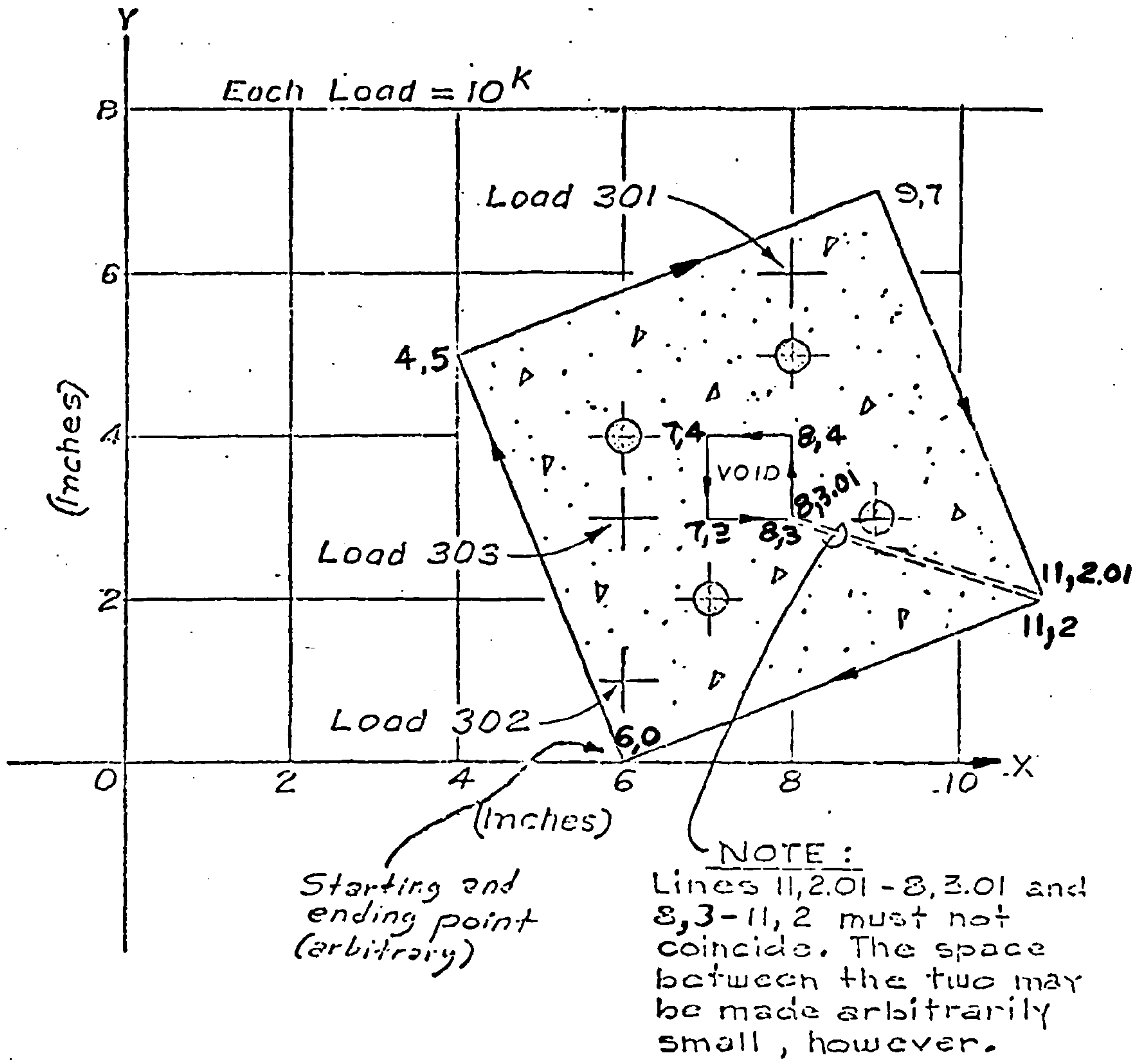
POINT	X-COORD	Y-COORD	COMPRESSIVE STRESS	POINT	X-COORD	Y-COORD	COMP. STRESS
1	0.	0.		2	0.	32.75	
3	21.50	32.75	0.131	4	21.50	0.	0.310
5	0.	0.					

STEEL STRESSES FOR PATTERN NO. 2:

AREA OF ONE BAR	QUAN. OF BARS/ROW	ROW END	X COORDINATE	Y COORDINATE	STRESS IN BAR
1.410	1		5.000	4.000	-2.187
1.410	1		5.000	28.750	-3.431
1.410	1		16.000	28.750	-0.205
1.410	1		16.000	4.000	0.

```
*FRN WESLIB/CORPS/X8008,R

ENTER 0 IF USING GRAPHICS TERMINAL.
   OR 1 IF NOT.
=1

ENTER 1 TO GET DETAILED STRESS TABLES,
   OR 0 TO GET MAXIMUM VALUES ONLY.
=0

INPUT NAME OF DATA FILE.
INCLUDE 'CAT$PASS/FILENAME$PASS'  ONLY, NO USER ID
IF YOU WISH TO INPUT DATA FROM TERMINAL, ENTER A
CARRIAGE RETURN.
 ? CGFAD1
ENTER NEW OUTPUT FILE NAME--CARRIAGE RETURN PRINTS
OUTPUT AT TERMINAL.
 ?

PROGRAM CORPS/X8008   CONCRETE GENERAL FLEXURE ANALYSIS  REV 82
 CGFA TEST PROBLEM 1 -- TAKEN FROM HINGE BASE PLATE, PORT ARTHUR
** I N P U T   L O A D I N G   A N D   P A R A M E T E R S **

LD. CASE       P     Y-AXIS MOM. X-AXIS MOM.     N      R     ACCURACY
    3        18.00      453.00       160.75    9.20   0.        0.010

S T R E S S   E Q U A T I O N   A N D   N E U T R A L   A X I S:

  UNIT STRESS =      0.03187 X  +    -0.00546 Y  +    -0.37519

 AT Y = 0, NEUTRAL AXIS CROSSES X-AXIS AT X =     11.772075
 AT X = 0, NEUTRAL AXIS CROSSES Y-AXIS AT Y =    -68.675287

        MAXIMUM CONCRETE STRESS =      0.31 AT POINT 4
        MAXIMUM STEEL STRESS    =      3.43 T

PROGRAM CORPS/X8008   CONCRETE GENERAL FLEXURE ANALYSIS  REV 82
 CGFA TEST PROBLEM 1 -- TAKEN FROM HINGE BASE PLATE, PORT ARTHUR
** I N P U T   L O A D I N G   A N D   P A R A M E T E R S **

LD. CASE       P     Y-AXIS MOM. X-AXIS MOM.     N      R     ACCURACY
    4        18.00      453.00       160.75    9.20   0.        0.001

S T R E S S   E Q U A T I O N   A N D   N E U T R A L   A X I S:

  UNIT STRESS =      0.03187 X  +    -0.00546 Y  +    -0.37519

 AT Y = 0, NEUTRAL AXIS CROSSES X-AXIS AT X =     11.772075
 AT X = 0, NEUTRAL AXIS CROSSES Y-AXIS AT Y =    -68.675287

        MAXIMUM CONCRETE STRESS =      0.31 AT POINT 4
        MAXIMUM STEEL STRESS    =      3.43 T
```

33. <u>Sample Problems 2 and 3.</u> Coding a void.



```
*LIST CGFAD2

3000  TEST PROBLEM 2 -- WITH 3 LOAD CASES
3010  11  3  3
3020  101  6  0  4  5  9  7
3022  101  11  2.01  8  3.01  8  4
3024  101  7  4  7  3  8  3
3026  101  11  2  6  0
3030  201  1  7  2  1
3032  201  1  6  4  1
3034  201  1  8  5  2  9  3
3040  301  10  80  50  10  2  0.01
3050  302  10  60  10  10  2  0
3060  303  10  60  30  10  2  0.01
4000  TEST PROBLEM 3 -- REPEAT PROBLEM 2 WITHOUT STEEL, 1 LOAD CASE
4010  0  0  1
4200  401  10  80  50  10  2  0.01

*FRN WESLIB/CORPS/X8008,R


ENTER 0 IF USING GRAPHICS TERMINAL.
   OR 1 IF NOT.
=0

COMPUTER WILL PAUSE TO ALLOW OUTPUT COPYING.
HIT CARRIAGE RETURN TO CONTINUE.

ENTER 1 TO GET DETAILED STRESS TABLES,
   OR 0 TO GET MAXIMUM VALUES ONLY.
=1

INPUT NAME OF DATA FILE.
INCLUDE 'CAT$PASS/FILENAME$PASS'  ONLY, NO USER ID
IF YOU WISH TO INPUT DATA FROM TERMINAL, ENTER A
CARRIAGE RETURN.
 ? CGFAD2
```

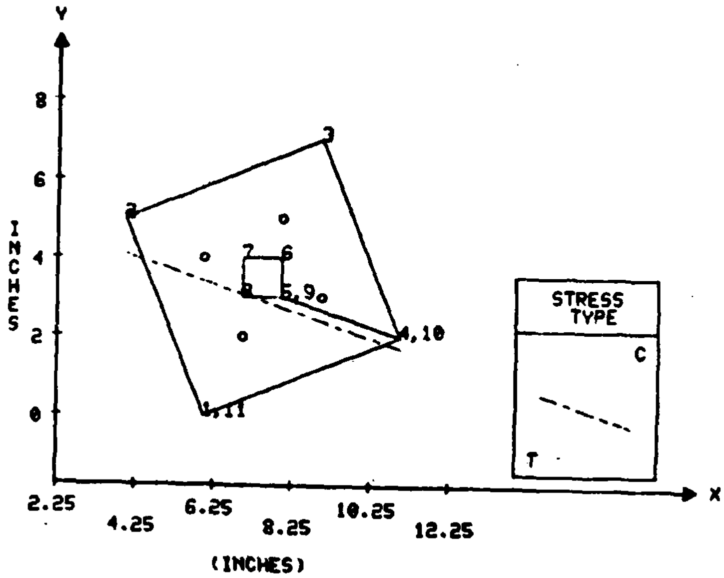
PROGRAM CORPS/X8008 CONCRETE GENERAL FLEXURE ANALYSIS REV 82
TEST PROBLEM 2 -- WITH 3 LOAD CASES
** I N P U T L O A D I N G A N D P A R A M E T E R S **

LD. CASE	P	Y-AXIS MOM.	X-AXIS MOM.	N	R	ACCURACY
301	10.00	80.00	50.00	10.00	2.00	0.010

S T R E S S E Q U A T I O N A N D N E U T R A L A X I S:

UNIT STRESS = 0.04013 X + 0.11904 Y + -0.64624

AT Y = 0, NEUTRAL AXIS CROSSES X-AXIS AT X = 16.101830
AT X = 0, NEUTRAL AXIS CROSSES Y-AXIS AT Y = 5.4285039



----- NEUTRAL AXIS (T=TENSION, C=COMPRESSION)

MAXIMUM CONCRETE STRESS = 0.55 AT POINT 3
MAXIMUM STEEL STRESS = 1.27 T
= 5.40 C

COMPRESSIVE STRESS IS SHOWN PLUS, TENSION MINUS (CONC. & STEEL)

C O N C R E T E S T R E S S E S F O R O U T L I N E 101:

POINT	X-COORD	Y-COORD	COMPRESSIVE STRESS	POINT	X-COORD	Y-COORD	COMP. STRESS
1	6.00	0.		2	4.00	5.00	0.110
3	9.00	7.00	0.548	4	11.00	2.01	0.035
5	8.00	3.01	0.033	6	8.00	4.00	0.151
7	7.00	4.00	0.111	8	7.00	3.00	
9	8.00	3.00	0.032	10	11.00	2.00	0.033
11	6.00	0.					

S T E E L S T R E S S E S F O R P A T T E R N NO. 201:

AREA OF ONE BAR	QUAN. OF BARS/ROW	ROW END	X COORDINATE	Y COORDINATE	STRESS IN BAR
1.000	1		7.000	2.000	-1.272
1.000	1		6.000	4.000	1.415
1.000	2	1	8.000	5.000	5.401
		2	9.000	3.000	1.442

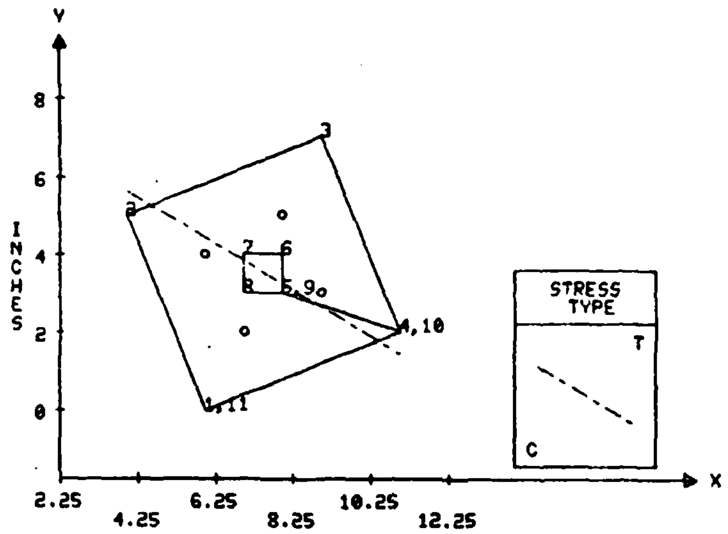
PROGRAM CORPS/X8008   CONCRETE GENERAL FLEXURE ANALYSIS   REV 82
TEST PROBLEM 2 -- WITH 3 LOAD CASES
** I N P U T   L O A D I N G   A N D   P A R A M E T E R S **

LD. CASE	P	Y-AXIS MOM.	X-AXIS MOM.	N	R	ACCURACY
302	10.00	60.00	10.00	10.00	2.00	0.010

S T R E S S   E Q U A T I O N   A N D   N E U T R A L   A X I S:

UNIT STRESS =   -0.13771 X   +   -0.23104 Y   +   1.84825

AT Y = 0, NEUTRAL AXIS CROSSES X-AXIS AT X =   13.421667
AT X = 0, NEUTRAL AXIS CROSSES Y-AXIS AT Y =   7.9996486



(INCHES)

----- NEUTRAL AXIS (T=TENSION, C=COMPRESSION)

MAXIMUM CONCRETE STRESS =   1.02 AT POINT 1
MAXIMUM STEEL STRESS   =   4.09 T
                       =   8.44 C

COMPRESSIVE STRESS IS SHOWN PLUS, TENSION MINUS (CONC. & STEEL)

C O N C R E T E   S T R E S S E S   F O R   O U T L I N E   101:

POINT	X-COORD	Y-COORD	COMPRESSIVE STRESS	POINT	X-COORD	Y-COORD	COMP. STRESS
1	6.00	0.	1.022	2	4.00	5.00	0.142
3	9.00	7.00		4	11.00	2.01	
5	8.00	3.01	0.051	6	8.00	4.00	
7	7.00	4.00		8	7.00	3.00	0.191
9	8.00	3.00	0.053	10	11.00	2.00	
11	6.00	0.	1.022				

S T E E L   S T R E S S E S   F O R   P A T T E R N   NO.   201:

AREA OF ONE BAR	QUAN. OF BARS/ROW	ROW END	X COORDINATE	Y COORDINATE	STRESS IN BAR
1.000	1		7.000	2.000	8.444
1.000	1		6.000	4.000	1.957
1.000	2	1	8.000	5.000	-4.086
		2	9.000	3.000	-0.842

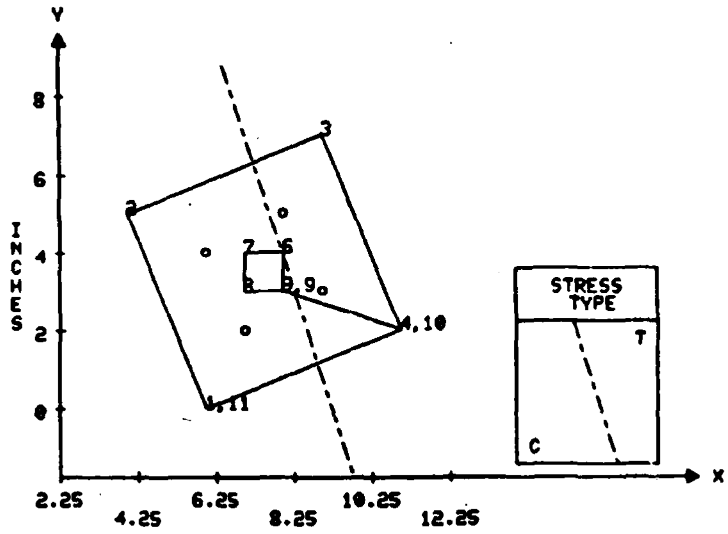
PROGRAM CORPS/X0008 CONCRETE GENERAL FLEXURE ANALYSIS REV 82
TEST PROBLEM 2 -- WITH 3 LOAD CASES
** INPUT LOADING AND PARAMETERS **

LD. CASE	P	Y-AXIS MOM.	X-AXIS MOM.	N	R	ACCURACY
303	10.00	60.00	30.00	10.00	2.00	0.010

STRESS EQUATION AND NEUTRAL AXIS:

UNIT STRESS = -0.11550 X + -0.03640 Y + 1.06525

AT Y = 0, NEUTRAL AXIS CROSSES X-AXIS AT X = 9.2226509
AT X = 0, NEUTRAL AXIS CROSSES Y-AXIS AT Y = 29.264735



----- NEUTRAL AXIS (T=TENSION, C=COMPRESSION)

MAXIMUM CONCRETE STRESS = 0.42 AT POINT 2
MAXIMUM STEEL STRESS = 0.83 T
= 4.53 C

COMPRESSIVE STRESS IS SHOWN PLUS, TENSION MINUS (CONC. & STEEL)

CONCRETE STRESSES FOR OUTLINE 101:

POINT	X-COORD	Y-COORD	COMPRESSIVE STRESS	POINT	X-COORD	Y-COORD	COMP. STRESS
1	6.00	0.	0.372	2	4.00	5.00	0.421
3	9.00	7.00		4	11.00	2.01	
5	8.00	3.01	0.032	6	8.00	4.00	
7	7.00	4.00	0.111	8	7.00	3.00	0.148
9	8.00	3.00	0.032	10	11.00	2.00	
11	6.00	0.	0.372				

STEEL STRESSES FOR PATTERN NO. 201:

AREA OF ONE BAR	QUAN. OF BARS/ROW	ROW END	X COORDINATE	Y COORDINATE	STRESS IN BAR
1.000	1		7.000	2.000	3.678
1.000	1		6.000	4.000	4.533
1.000	2	1	8.000	5.000	-0.408
		2	9.000	3.000	-0.835

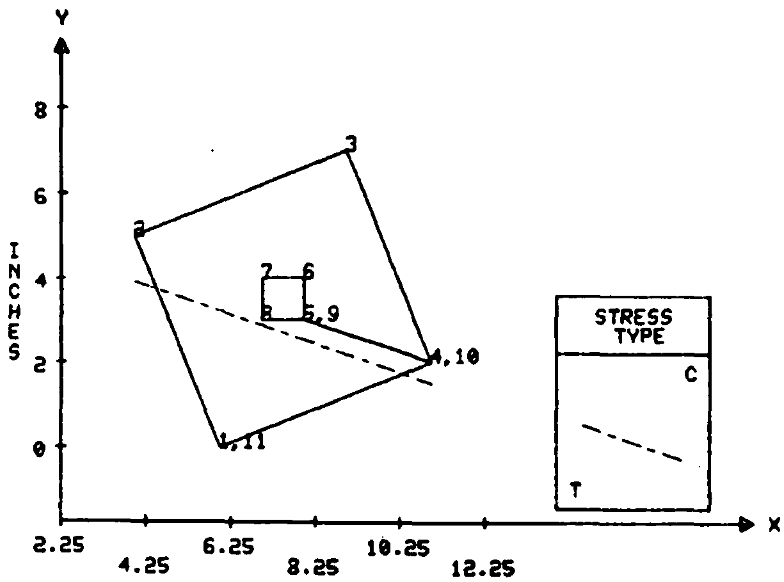
PROGRAM CORPS/X8008 CONCRETE GENERAL FLEXURE ANALYSIS REV 82
TEST PROBLEM 3 -- REPEAT PROBLEM 2 WITHOUT STEEL, 1 LOAD CASE
** INPUT LOADING AND PARAMETERS **

LD. CASE	P	Y-AXIS MOM.	X-AXIS MOM.	N	R	ACCURACY
401	10.00	80.00	50.00	10.00	2.00	0.010

STRESS EQUATION AND NEUTRAL AXIS:

UNIT STRESS = 0.10647 X + 0.30871 Y + -1.63271

AT Y = 0, NEUTRAL AXIS CROSSES X-AXIS AT X = 15.334591
AT X = 0, NEUTRAL AXIS CROSSES Y-AXIS AT Y = 5.2887872



----- NEUTRAL AXIS (T=TENSION, C=COMPRESSION)

MAXIMUM CONCRETE STRESS = 1.49 AT POINT 3

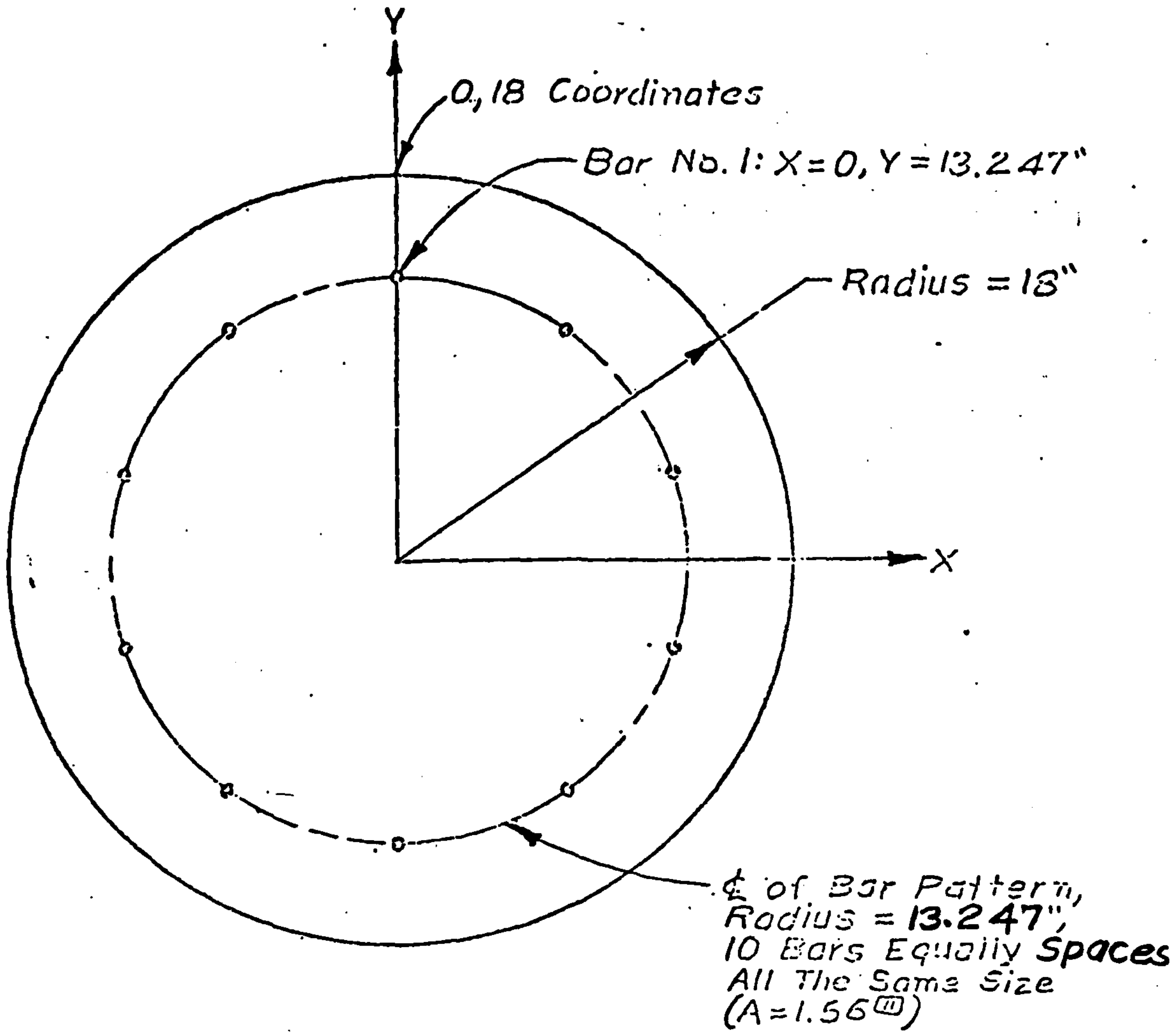
COMPRESSIVE STRESS IS SHOWN PLUS, TENSION MINUS (CONC. & STEEL)

CONCRETE STRESSES FOR OUTLINE 101:

POINT	X-COORD	Y-COORD	COMPRESSIVE STRESS	POINT	X-COORD	Y-COORD	COMP. STRESS
1	6.00	0.		2	4.00	5.00	0.337
3	9.00	7.00	1.487	4	11.00	2.01	0.159
5	8.00	3.01	0.148	6	8.00	4.00	0.454
7	7.00	4.00	0.347	8	7.00	3.00	0.039
9	8.00	3.00	0.145	10	11.00	2.00	0.156
11	6.00	0.		12	0.	0.	0.

*

34. **Sample Problem 4.** Round section.



Above data generated by Program [713-G1-M3190 X0009], using these data:

Center at coordinates X = 0.0 , Y = 0.0
Radius of outline = 18.0
Radius of void = 0.0
No. of reinforcing bars = 10
Clear cover over reinforcing bars = 4.0
Bar size = No. 11

```
*LIST CGFAD4

1010 TEST PROBLEM 4 -- DATA GENERATED BY PROGRAM CORPS/X0009
1020  37          10          1
1040    401      0.        18.00      3.13     17.73      6.16     16.91
1042    401      9.00      15.59     11.57     13.79     13.79     11.57
1044    401     15.59       9.00     16.91      6.16     17.73      3.13
1046    401     18.00      -0.00     17.73     -3.13     16.91     -6.16
1048    401     15.59      -9.00     13.79    -11.57     11.57    -13.79
1050    401      9.00     -15.59      6.16    -16.91      3.13    -17.73
1052    401     -0.00     -18.00     -3.13    -17.73     -6.16    -16.91
1054    401     -9.00     -15.59    -11.57    -13.79    -13.79    -11.57
1056    401    -15.59      -9.00    -16.91     -6.16    -17.73     -3.13
1058    401    -18.00       0.00    -17.73      3.13    -16.91      6.16
1060    401    -15.59       9.00    -13.79     11.57    -11.57     13.79
1062    401     -9.00      15.59     -6.16     16.91     -3.13     17.73
1064    401      0.        18.00      0.        0.        0.        0.
1080    402    1.56        0.          13.29    1
1082    402    1.56        7.81        10.76    1
1084    402    1.56       12.64         4.11    1
1086    402    1.56       12.64        -4.11    1
1088    402    1.56        7.81       -10.76    1
1090    402    1.56       -0.00       -13.29    1
1092    402    1.56       -7.81       -10.76    1
1094    402    1.56      -12.64        -4.11    1
1096    402    1.56      -12.64         4.11    1
1098    402    1.56       -7.81        10.76    1
1100   403  1060  0   4800000  9.2  1  1
1610   0         0         0
1620   0         0         0

*FRN WESLIB/CORPS/X8008,R
```

```
ENTER 0 IF USING GRAPHICS TERMINAL.
   OR 1 IF NOT.
*0

COMPUTER WILL PAUSE TO ALLOW OUTPUT COPYING.
HIT CARRIAGE RETURN TO CONTINUE.

ENTER 1 TO GET DETAILED STRESS TABLES,
   OR 0 TO GET MAXIMUM VALUES ONLY.
*1

INPUT NAME OF DATA FILE.
INCLUDE 'CAT$PASS/FILENAME$PASS'  ONLY, NO USER ID
IF YOU WISH TO INPUT DATA FROM TERMINAL, ENTER A
CARRIAGE RETURN.
 ? CGFAD4
```

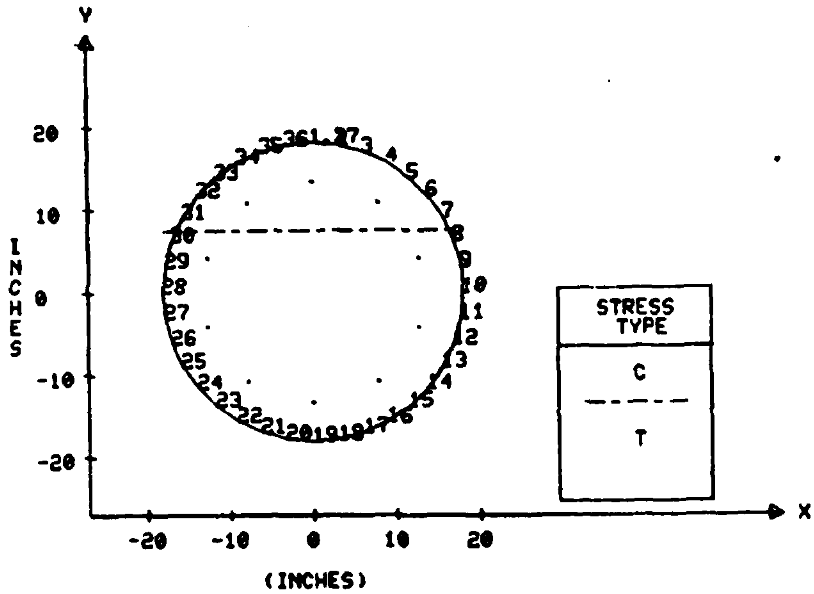
PROGRAM CORPS/X8008 CONCRETE GENERAL FLEXURE ANALYSIS REV 82
TEST PROBLEM 4 -- DATA GENERATED BY PROGRAM CORPS/X0009
** INPUT LOADING AND PARAMETERS **

LD. CASE	P	Y-AXIS MOM.	X-AXIS MOM.	N	R	ACCURACY
403	1060.00	0.	4800000.00	9.20	1.00	1.000

STRESS EQUATION AND NEUTRAL AXIS:

UNIT STRESS = -0.00000 X + 176.96829 Y + -1306.35403

AT Y = 0, NEUTRAL AXIS CROSSES X-AXIS AT X = -0.20807982E 10
AT X = 0, NEUTRAL AXIS CROSSES Y-AXIS AT Y = 7.3818538



----- NEUTRAL AXIS (T=TENSION, C=COMPRESSION)

MAXIMUM CONCRETE STRESS = 1879.08 AT POINT 1
MAXIMUM STEEL STRESS = 33656.02 T
= 9619.10 C

COMPRESSIVE STRESS IS SHOWN PLUS, TENSION MINUS (CONC. & STEEL)

C O N C R E T E   S T R E S S E S   F O R   O U T L I N E   401:

POINT	X-COORD	Y-COORD	COMPRESSIVE STRESS	POINT	X-COORD	Y-COORD	COMP. STRESS
1	0.	18.00	1879.075	2	3.13	17.73	1831.294
3	6.16	16.91	1686.180	4	9.00	15.59	1452.582
5	11.57	13.79	1134.039	6	13.79	11.57	741.169
7	15.59	9.00	286.361	8	16.91	6.16	
9	17.73	3.13		10	18.00	0.	
11	17.73	-3.13		12	16.91	-6.16	
13	15.59	-9.00		14	13.79	-11.57	
15	11.57	-13.79		16	9.00	-15.59	
17	6.16	-16.91		18	3.13	-17.73	
19	0.	-18.00		20	-3.13	-17.73	
21	-6.16	-16.91		22	-9.00	-15.59	
23	-11.57	-13.79		24	-13.79	-11.57	
25	-15.59	-9.00		26	-16.91	-6.16	
27	-17.73	-3.13		28	-18.00	0.	
29	-17.73	3.13		30	-16.91	6.16	
31	-15.59	9.00	286.361	32	-13.79	11.57	741.169
33	-11.57	13.79	1134.039	34	-9.00	15.59	1452.582
35	-6.16	16.91	1686.180	36	-3.13	17.73	1831.294
37	0.	18.00	1879.075				

S T E E L   S T R E S S E S   F O R   P A T T E R N   NO.   402:

AREA OF ONE BAR	QUAN. OF BARS/ROW	ROW END	X COORDINATE	Y COORDINATE	STRESS IN BAR
1.560	1		0.	13.290	9619.102
1.560	1		7.810	10.760	5499.988
1.560	1		12.640	4.110	-5326.932
1.560	1		12.640	-4.110	-18709.982
1.560	1		7.810	-10.760	-29536.902
1.560	1		0.	-13.290	-33656.016
1.560	1		-7.810	-10.760	-29536.902
1.560	1		-12.640	-4.110	-18709.982
1.560	1		-12.640	4.110	-5326.932
1.560	1		-7.810	10.760	5499.988

35. <u>Problem 2.</u> **Interactive input.**

```
◆FRN WESLIB/CORPS/X8008,R

ENTER 0 IF USING GRAPHICS TERMINAL.
   OR 1 IF NOT.
=1

ENTER 1 TO GET DETAILED STRESS TABLES,
   OR 0 TO GET MAXIMUM VALUES ONLY.
=0

INPUT NAME OF DATA FILE.
INCLUDE 'CAT$PASS/FILENAME$PASS'  ONLY, NO USER ID
IF YOU WISH TO INPUT DATA FROM TERMINAL, ENTER A
CARRIAGE RETURN.
 ?
ENTER NEW NAME FOR DATA FILE TO BE CREATED, OR
TYPE CARRIAGE RETURN IF YOU DO NOT WISH TO SAVE DATA.
 ? CGFAD5
ENTER NEW OUTPUT FILE NAME--CARRIAGE RETURN PRINTS
OUTPUT AT TERMINAL.
 ?
°81k
DATA ARE ENTERED IN GROUPS THAT WILL BE DESCRIBED
IN THE ORDER OF THEIR ENTRY--ALONG WITH AN
IDENTIFYING SYMBOL FOR EACH GROUP.  SEPARATE
DATA ON EACH LINE BY COMMAS OR AT LEAST ONE
SPACE.  YOU MAY REQUEST SHORT CUES FOR IDENTIFYING
SYMBOLS ONLY.  SYMBOLS ARE:
      ◆ = TITLE LINE
      # = HEADER LINE
      $ = CONCRETE DATA LINES
      % = STEEL DATA LINES
      ! = LOADING DATA LINES

SHORT OR LONG CUES?(SH OR LO)
 ? LO
GROUP  ◆ :  ENTER TITLE FOR THIS PROGRAM.
◆    1 ? TEST PROBLEM 2 REPEATED

DO YOU WANT TO:
    'LOOK'    - VIEW DATA IN THIS GROUP
    'CHANGE'  - CORRECT DATA LINE(S) IN THIS GROUP
    'RETRY'   - DISCARD DATA ENTERED IN THIS GROUP & ENTER IT AGAIN
    'END'     - DATA IN THIS GROUP IS CORRECT (SAVE AND CONTINUE)

ENTER (LOOK,CHANGE,RETRY,END) ? END

THIS DATA GROUP COMPLETE - CONTINUE
```

```
GROUP  # :  ENTER NUMBER OF CONCRETE DATA POINTS
(FOR FIRST PROBLEM       - 0 - MEANS NO CONCRETE DATA POINTS
FOR ADDITIONAL PROBLEMS - 0 - MEANS RETAIN CONCRETE DATA
                              POINTS FROM PRECEEDING PROBLEM),
NUMBER OF STEEL DATA LINES, AND NUMBER OF LOAD
DATA LINES.
#     1 ? 11, 3, 3

ENTER (LOOK,CHANGE,RETRY,END) ? END

THIS DATA GROUP COMPLETE - CONTINUE
GROUP  $ :  ENTER CONCRETE I.D. NUMBER.
$     1 ? 101

ENTER (LOOK,CHANGE,RETRY,END) ? END

THIS DATA GROUP COMPLETE - CONTINUE
ENTER  11 SETS OF  X  AND  Y  COORDINATES
TO DEFINE CONCRETE GEOMETRY.   (ONE SET PER LINE)
$     1 ? 6, 0
$     2 ? 4, 5
$     3 ? 9, 7
$     4 ? 11, 2
$     5 ? 8, 3
$     6 ? 8, 4
$     7 ? 7, 4
$     8 ? 7, 3
$     9 ? 8, 3
$    10 ? 11, 2
$    11 ? 6, 0

ENTER (LOOK,CHANGE,RETRY,END) ? CHANGE

ENTER ITEM NO. TO BE CORRECTED
ENTER 999 TO TERMINATE CHANGES
 ? 4

ENTER CORRECTED DATA STRING
 ? 11, 2.01
ENTER NEXT ITEM NO.
 ? 5

ENTER CORRECTED DATA STRING
 ? 8, 3.01
ENTER NEXT ITEM NO.999
 ? 999

ENTER (LOOK,CHANGE,RETRY,END) ? LOOK

ITEM     DATA STRING AS ENTERED
 NO.
  1     6, 0
  2     4, 5
  3     9, 7
  4     11, 2.01
  5     8, 3.01
  6     8, 4
  7     7, 4
  8     7, 3
  9     8, 3
 10     11, 2
 11     6, 0

ENTER (LOOK,CHANGE,RETRY,END) ? END
```

```
THIS DATA GROUP COMPLETE - CONTINUE
GROUP  % :  ENTER ONE LINE OF STEEL DATA FOR
EACH ROW.  FOR ROWS OF ONE BAR, ENTER STEEL DATA
I.D. NUMBER, THE CROSS-SECTIONAL AREA OF BARS, THE
X-COORDINATE OF BAR LOCATION, THE Y-COORDINATE OF
THE BAR, AND A NUMERAL '1'.  FOR ROWS OF MORE THAN
ONE BAR, ENTER STEEL DATA I.D. NUMBER, CROSS-SECTIONAL
AREA OF ONE BAR IN THE ROW, X-COORDINATE OF END
NUMBER 1 OF THE ROW, Y-COORDINATE OF ROW, NUMBER
OF BARS ON THE ROW, X-COORDINATE OF END NUMBER 2
OF ROW, AND Y-COORDINATE OF END NUMBER 2.
%     1 ? 201, 1.00, 7, 2, 1
%     2 ? 201, 1.00, 6, 4, 1
%     3 ? 201, 1.00, 8, 5, 2, 9, 3

ENTER (LOOK,CHANGE,RETRY,END) ? END

THIS DATA GROUP COMPLETE - CONTINUE
GROUP  ! :  ENTER THE LOADING DATA ONE LINE
AT A TIME IN THE FOLLOWING ORDER:  LOAD CASE I.D.
NUMBER, THE AXIAL LOAD, THE MOMENT  MX  ABOUT
THE Y-AXIS, THE MOMENT  MY  ABOUT THE X-AXIS, THE
MODULAR RATIO 'N', AND THE DESIRED ACCURACY OF
THE CONCRETE STRESSES.
!     1 ? 301, 10, 80, 50, 10, 2, 0.01
!     2 ? 302, 10, 60, 10, 10, 2, 0
!     3 ? 303, 10, 60, 30, 10, 2, 0.01

ENTER (LOOK,CHANGE,RETRY,END) ? END

THIS DATA GROUP COMPLETE - CONTINUE
DO YOU WANT TO ENTER ANOTHER PROBLEM AS PART OF THIS
DATA FILE (YES OR NO) ? YES
GROUP  + :  ENTER TITLE FOR THIS PROGRAM.
+     1 ? TEST PROBLEM 3 -- PROB. 2 WITHOUT STEEL

ENTER (LOOK,CHANGE,RETRY,END) ? END

THIS DATA GROUP COMPLETE - CONTINUE
GROUP  # :  ENTER NUMBER OF CONCRETE DATA POINTS
(FOR FIRST PROBLEM        - 0 - MEANS NO CONCRETE DATA POINTS
FOR ADDITIONAL PROBLEMS - 0 - MEANS RETAIN CONCRETE DATA
                              POINTS FROM PRECEEDING PROBLEM),
NUMBER OF STEEL DATA LINES, AND NUMBER OF LOAD
DATA LINES.
#     1 ? 0, 0, 1

ENTER (LOOK,CHANGE,RETRY,END) ? END

THIS DATA GROUP COMPLETE - CONTINUE
GROUP  ! :  ENTER THE LOADING DATA ONE LINE
AT A TIME IN THE FOLLOWING ORDER:  LOAD CASE I.D.
NUMBER, THE AXIAL LOAD, THE MOMENT  MX  ABOUT
THE Y-AXIS, THE MOMENT  MY  ABOUT THE X-AXIS, THE
MODULAR RATIO 'N', AND THE DESIRED ACCURACY OF
THE CONCRETE STRESSES.
!     1 ? 301, 10, 80, 50, 10, 2, 0.01

ENTER (LOOK,CHANGE,RETRY,END) ? LOOK
```

```
ITEM    DATA STRING AS ENTERED
 NO.
  1     301, 10, 80, 50, 10, 2, 0.01

ENTER (LOOK,CHANGE,RETRY,END) ? END

THIS DATA GROUP COMPLETE - CONTINUE
DO YOU WANT TO ENTER ANOTHER PROBLEM AS PART OF THIS
DATA FILE (YES OR NO) ? NO
```

```
 PROGRAM CORPS/X8008   CONCRETE GENERAL FLEXURE ANALYSIS  REV 82
  TEST PROBLEM 2 REPEATED
 ** I N P U T   L O A D I N G   A N D   P A R A M E T E R S **

LD. CASE       P     Y-AXIS MOM. X-AXIS MOM.    N      R     ACCURACY
   301       10.00       80.00       50.00   10.00  2.00      0.010

 S T R E S S   E Q U A T I O N   A N D   N E U T R A L   A X I S:

   UNIT STRESS =      0.04013 X  +     0.11904 Y  +    -0.64624

  AT Y = 0, NEUTRAL AXIS CROSSES X-AXIS AT X =     16.101830
  AT X = 0, NEUTRAL AXIS CROSSES Y-AXIS AT Y =     5.4285039

         MAXIMUM CONCRETE STRESS =      0.55 AT POINT 3
         MAXIMUM STEEL STRESS    =      1.27 T
                                 =      5.40 C
```

```
 PROGRAM CORPS/X8008   CONCRETE GENERAL FLEXURE ANALYSIS  REV 82
  TEST PROBLEM 2 REPEATED
 ** I N P U T   L O A D I N G   A N D   P A R A M E T E R S **

LD. CASE       P     Y-AXIS MOM. X-AXIS MOM.    N      R     ACCURACY
   302       10.00       60.00       10.00   10.00  2.00      0.010

 S T R E S S   E Q U A T I O N   A N D   N E U T R A L   A X I S:

   UNIT STRESS =    -0.13771 X  +    -0.23104 Y  +      1.84825

  AT Y = 0, NEUTRAL AXIS CROSSES X-AXIS AT X =     13.421667
  AT X = 0, NEUTRAL AXIS CROSSES Y-AXIS AT Y =     7.9996486

         MAXIMUM CONCRETE STRESS =      1.02 AT POINT 1
         MAXIMUM STEEL STRESS    =      4.09 T
                                 =      8.44 C
```

```
PROGRAM CORPS/X8008   CONCRETE GENERAL FLEXURE ANALYSIS   REV 82
 TEST PROBLEM 2 REPEATED
** I N P U T   L O A D I N G   A N D   P A R A M E T E R S **

LD. CASE       P     Y-AXIS MOM. X-AXIS MOM.    N      R     ACCURACY
  303        10.00       60.00        30.00  10.00  2.00    0.010

S T R E S S   E Q U A T I O N   A N D   N E U T R A L   A X I S:

  UNIT STRESS =     -0.11550 X  +    -0.03640 Y  +     1.06525

 AT Y = 0, NEUTRAL AXIS CROSSES X-AXIS AT X =      9.2226509
 AT X = 0, NEUTRAL AXIS CROSSES Y-AXIS AT Y =      29.264735

        MAXIMUM CONCRETE STRESS =       0.42 AT POINT 2
        MAXIMUM STEEL STRESS    =       0.83 T
                                =       4.53 C


PROGRAM CORPS/X8008   CONCRETE GENERAL FLEXURE ANALYSIS   REV 82
 TEST PROBLEM 3 -- PROB. 2 WITHOUT STEEL
** I N P U T   L O A D I N G   A N D   P A R A M E T E R S **

LD. CASE       P     Y-AXIS MOM. X-AXIS MOM.    N      R     ACCURACY
  301        10.00       80.00        50.00  10.00  2.00    0.010

S T R E S S   E Q U A T I O N   A N D   N E U T R A L   A X I S:

  UNIT STRESS =      0.10647 X  +     0.30871 Y  +    -1.63271

 AT Y = 0, NEUTRAL AXIS CROSSES X-AXIS AT X =      15.334591
 AT X = 0, NEUTRAL AXIS CROSSES Y-AXIS AT Y =      5.2887872

        MAXIMUM CONCRETE STRESS =      1.49 AT POINT 3
```

```
*LIST CGFAD5

3000 TEST PROBLEM 2 REPEATED
3010    11    3    3
3020 101         6.00      0.        4.00      5.00      9.00      7.00
3030 101        11.00      2.01      8.00      3.01      8.00      4.00
3040 101         7.00      4.00      7.00      3.00      8.00      3.00
3050 101        11.00      2.00      6.00      0.
3060 201, 1.00, 7, 2, 1
3070 201, 1.00, 6, 4, 1
3080 201, 1.00, 8, 5, 2, 9, 3
3090 301, 10, 80, 50, 10, 2, 0.01
3100 302, 10, 60, 10, 10, 2, 0
3110 303, 10, 60, 30, 10, 2, 0.01
3120 TEST PROBLEM 3 -- PROB. 2 WITHOUT STEEL
3130      0     0     1
3140 301, 10, 80, 50, 10, 2, 0.01
3150
3160 0,0,0
```

APPENDIX A: ABSTRACT ON PROGRAM X0009

CATEGORY B

ELECTRONIC COMPUTER PROGRAM ABSTRACT

TITLE OF PROGRAM CGFARD - Round Data Generator for Program 713-F3-R0010 (CGFA) (X0009)	PROGRAM NO. 713-F3-R0011
PREPARING AGENCY US Army Engineer Waterways Experiment Station, Automatic Data Processing Center, PO Box 631, Vicksburg, MS 39180	

AUTHOR(S)	DATE PROGRAM COMPLETED	STATUS OF PROGRAM: PHASE	STATUS OF PROGRAM: STAGE
William A. Price III, Struct Engr FTS 542-3645	December 1974		OP

A. PURPOSE OF PROGRAM

To generate concrete outline and/or steel pattern data cards for use with Program 713-F3-R0010, "Concrete General Flexure Analysis" (CGFA), working from the usual parameters used to describe reinforced concrete construction x or by defining radii and bar sizes and locations.

B. PROGRAM SPECIFICATIONS

The program is written in G-6000 FORTRAN, for Timesharing.

C. METHODS

37 coordinates sets are generated for the concrete outline circle; if the radius of a concentric void is coded, a total of 74 coordinate sets are generated for the complete concrete outline description plus a repeat of the first set. The specified number of reinforcing bars are equally spaced in a concentric circle, with one bar on the +y=axis.

D. EQUIPMENT DETAILS

G-635 Computer.

Remote terminal (asynchronous)

E. INPUT-OUTPUT

Terminal Input: x and y coordinates of center of cross-section radii of concrete outline and concentric void (if any), quantity and size number of reinforcing bars, clear cover over the bars, and identification number codes for the concrete and steel lines to be generated.

Output: Writes a data file to which the load data lines are added to make a complete data file for CGFA (X0008 in CORPS).

F. ADDITIONAL REMARKS

1. The concrete lines can be omitted, for a circular steel pattern to be added to a non-circular outline.
2. By computing two concrete outlines and discarding half of each set of concrete points, a rounded-end wall outline can be generated.
3. This is the time-sharing version of program 713-G1-M3170.
4. Program is available through CORPS.

CYBERNET System

The log-on procedure is followed by a call to the CORPS procedure file

OLD, CORPS/UN=CECELB

to access the CORPS library. The file name of the program is used in the command

BEGIN,,CORPS,X8ØØ8

to initiate execution of the program. An example is:

```
84/12/05.  16.41.ØØ.  AC2F5DA
EASTERN CYBERNET CENTER SN9Ø4 NOS   1.4/531.669/2ØAD
FAMILY:  KOE
USER NAME:  CEROXX
PASSWORD -
XXXXXXXX
TERMINAL:  23, NAMIAF
RECOVER/CHARGE:  CHARGE, CEROEGC, CEROXX
$CHARGE,
12.49.Ø7.  WARNING

11/29 FOR IMPORTANT INFO TYPE EXPLAIN, WARNING.
OLD, CORPS/UN=CECELB
/BEGIN,,CORPS,CORPS,X8ØØ8
```

Harris 500 System

The log-on procedure is followed by a call to the program executable file, with the user typing the asterisk and file description

*CORPS,X8ØØ8

to initiate execution of the program. An example is

```
"ACOE-ABLESVILLE (H500 V3.1)"
ENTER SIGN-ON
1234ABC,STRUCT

**GOOD MORNING STRUCTURES, IT'S 7 DEC 84 08:33:12
AED HARRIS 500 OPERATING HOURS 0700-1800 M-S
*CORPS,X8ØØ8
```

How to Use CORPS

The CORPS system contains many other useful programs which may be catalogued from CORPS by use of the LIST command. The execute command for CORPS on Honeywell systems is:

PROGRAM INFORMATION

Description of Program

CGFAG, called X8008 in the Conversationally Oriented Real-Time Program-Generating System (CORPS) library, is a general-purpose computer program for the working-stress analysis of reinforced concrete flexural members and base plate pads. The concrete section or base plate contact surface may be any polygon with no more than 100 sides.

Coding and Data Format

CGFAG is written in FORTRAN and is operational on the following systems:

a. Division office Honeywell DPS.

b. District office Harris 500 systems.

c. Cybernet Computer Service.

Data can be input interactively at execute time or from a prepared data file with line numbers. Output will come directly back to the terminal. A Tektronix 4014 graphics terminal is required if the optional graphics display is used.

How to Use CGFAG

A guide for accessing the program on each of the three systems is provided below. It is assumed that the user can sign on the appropriate system before attempting to use CGFAG. In the example initiation of execution commands below, all user responds are underlined, and each should be followed by a carriage return.

Honeywell Systems

After the user has signed on the system, the time-sharing command FORT brings the user to the level to execute the program. Next, the user issues the run command.

RUN WESLIB/CORPS/X8ØØ8,R

to initiate execution of the program. The program is then run as described in this user's guide. The data file should be prepared prior to issuing the RUN command. An example initiation of execution is as follows, assuming a data file has previously been prepared:

```
HIS TIMESHARING ON Ø3/Ø4/81 AT 13.3Ø1 CHANNEL 5647
USER ID - RØKACASECON
PASSWORD - XXXXXXXXXXXXXX
*FORT
*RUN WESLIB/CORPS/X8ØØ8,R
```

```
RUN WESLIB/CORPS/CORPS,R
ENTER COMMAND (HELP,LIST,BRIEF,MESSAGE,EXECUTE, OR STOP)
*?LIST
```

on the Cybernet system, the commands are:

```
OLD,CORPS/UN=CECELB
CALL,CORPS
ENTER COMMAND (HELP,LIST,BRIEF,MESSAGE,EXECUTE, OR STOP)
*?LIST
```

WATERWAYS EXPERIMENT STATION REPORTS PUBLISHED UNDER THE COMPUTER-AIDED STRUCTURAL ENGINEERING (CASE) PROJECT

	Title	Date
Technical Report K-78-1	List of Computer Programs for Computer-Aided Structural Engineering	Feb 1978
Instruction Report O-79-2	User's Guide: Computer Program with Interactive Graphics for Analysis of Plane Frame Structures (CFRAME)	Mar 1979
Technical Report K-80-1	Survey of Bridge-Oriented Design Software	Jan 1980
Technical Report K-80-2	Evaluation of Computer Programs for the Design/Analysis of Highway and Railway Bridges	Jan 1980
Instruction Report K-80-1	User's Guide: Computer Program for Design/Review of Curvilinear Conduits/Culverts (CURCON)	Feb 1980
Instruction Report K-80-3	A Three-Dimensional Finite Element Data Edit Program	Mar 1980
Instruction Report K-80-4	A Three-Dimensional Stability Analysis/Design Program (3DSAD)	
	Report 1: General Geometry Module	Jun 1980
	Report 3: General Analysis Module (CGAM)	Jun 1982
	Report 4: Special-Purpose Modules for Dams (CDAMS)	Aug 1983
Instruction Report K-80-6	Basic User's Guide: Computer Program for Design and Analysis of Inverted-T Retaining Walls and Floodwalls (TWDA)	Dec 1980
Instruction Report K-80-7	User's Reference Manual: Computer Program for Design and Analysis of Inverted-T Retaining Walls and Floodwalls (TWDA)	Dec 1980
Technical Report K-80-4	Documentation of Finite Element Analyses	
	Report 1: Longview Outlet Works Conduit	Dec 1980
	Report 2: Anchored Wall Monolith, Bay Springs Lock	Dec 1980
Technical Report K-80-5	Basic Pile Group Behavior	Dec 1980
Instruction Report K-81-2	User's Guide: Computer Program for Design and Analysis of Sheet Pile Walls by Classical Methods (CSHTWAL)	
	Report 1: Computational Processes	Feb 1981
	Report 2: Interactive Graphics Options	Mar 1981
Instruction Report K-81-3	Validation Report: Computer Program for Design and Analysis of Inverted-T Retaining Walls and Floodwalls (TWDA)	Feb 1981
Instruction Report K-81-4	User's Guide: Computer Program for Design and Analysis of Cast-in-Place Tunnel Linings (NEWTUN)	Mar 1981
Instruction Report K-81-6	User's Guide: Computer Program for Optimum Nonlinear Dynamic Design of Reinforced Concrete Slabs Under Blast Loading (CBARCS)	Mar 1981
Instruction Report K-81-7	User's Guide: Computer Program for Design or Investigation of Orthogonal Culverts (CORTCUL)	Mar 1981
Instruction Report K-81-9	User's Guide: Computer Program for Three-Dimensional Analysis of Building Systems (CTABS80)	Aug 1981
Technical Report K-81-2	Theoretical Basis for CTABS80: A Computer Program for Three-Dimensional Analysis of Building Systems	Sep 1981
Instruction Report K-82-6	User's Guide: Computer Program for Analysis of Beam-Column Structures with Nonlinear Supports (CBEAMC)	Jun 1982
Instruction Report K-82-7	User's Guide: Computer Program for Bearing Capacity Analysis of Shallow Foundations (CBEAR)	Jun 1982

(Continued)

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